BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: ALSEP Flight Support Systems Evaluation - Case 900

DATE: September 6, 1968

FROM: B. H. Liebowitz
R. J. Pauly

ABSTRACT

The proposals developed by MSC and KSC for an ALSEP flight support system meet the stated requirements. Cost considerations favor the KSC approach. Qualitative considerations favor MSC.

We recommend that MSC be selected, but with the following principal constraints to reduce costs:

1. Eliminate the Digital TV display capability from the flight support system.
2. Evaluate alternative methods of interfacing with the MSFN, e.g., the use of the Communications Command and Telemetry System, the use of 2.4 KB lines.
3. Restrict ALSEP flight support to a single IBM 360/50 computer.
4. Establish the concept that the IBM 360/50 computer is a multi-purpose computer, not dedicated to ALSEP.

BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: ALSEP Flight Support Systems Evaluation - Case 900

DATE: September 6, 1968

FROM: B. H. Liebowitz
R. J. Pauly

MEMORANDUM FOR FILE

INTRODUCTION

A proposal was prepared by MSC which indicated the resources it would need to develop an Apollo Lunar Surface Experiments Package (ALSEP) flight support system. After reviewing the proposal, Dr. G. E. Mueller asked that inquiries be made to see if one of the other NASA Centers could perform the flight support function with existing resources. In response, an ALSEP flight support system proposal was developed by KSC.

At the request of Maj. Gen. J. D. Stevenson, MO, Bellcomm performed a comparative evaluation of the MSC and KSC proposals. The results of the evaluation, presented in this memorandum, were given as an oral presentation to Gen. Stevenson on June 28, 1968.

MSC ALSEP FLIGHT SUPPORT SYSTEM PROPOSAL*

MSC proposed a single flight support system, which would provide simultaneous support for two ALSEPs. (See Figures 1 and 2). The basic features of the system are as follows:

1. ALSEP telemetry data would be collected by the MSFC and routed from GSFC to MSC via a 40.8 KBPS data circuit.

2. At MSC, the data would be routed to an IBM 360/50 computer, with 524,288 8-bit bytes of core storage via an MSFN interface terminal.

3. The computer would decommutate, calibrate and limit check the data, and perform special computations.

*For completeness, this section and the succeeding one have been reprinted from: "Trip Report: ALSEP Flight Control Support System," Bellcomm Memorandum for File, R. J. Pauly, August 1, 1968.

4. The data would be output from the computer to analog strip chart recorders, drum recorders, lights, meters, octal/decimal readouts, high-speed printers and digital TV displays.

5. Commands would be initiated by a push-button entry console input to the computer and routed to the MSFN via a 40.8 KBPS circuit from MSC to GSFC.

The MSC design is based on producing a flight support system which is compatible with the existing Mission Control Center systems. Existing resources would be used where possible. The proposed IBM 360/50 computer is on rental at MSC and would be available for the ALSEP support function. This computer could be used for functions other than ALSEP when time is available. It may also be feasible to time-share the computer so that other functions can be supported during an ALSEP control period.

KSC ALSEP FLIGHT SUPPORT SYSTEM PROPOSAL

KSC proposed two identical flight support systems, which would provide simultaneous support for two ALSEPs (See Figure 3). One system would be dedicated to each ALSEP. The basic features of the systems are as follows:

1. ALSEP telemetry data would be collected by the MSFN and routed from GSFC to KSC via a 2.4 KBPS data circuit.

2. At KSC, the data would be partially decommed by a PCM ground station, and input to an SDS 930 computer with 32,000 24-bit words of core storage.

3. The computer would complete the decommutation and calibrate and limit check the data.

4. The data would be output from the computer to analog strip chart recorders, drum recorders, lights, meters, octal/decimal readouts, and a high-speed line printer.

5. Commands would be initiated by a typewriter input to the computer and routed to the MSFN via a 2.4 KBPS circuit from KSC to GSFC.

The KSC flight support system would be totally dedicated and tailored to ALSEP support. Existing resources would be used where possible. The proposal assumes that two SDS 930 computers could be obtained from MSFC. There appears to be ample facilities available to house the support system.

SUMMARY OF IDENTIFIABLE COSTS

A comparison of the identifiable costs for the two flight support systems is presented below.* The costs are for developing and operating the systems over a three year period. The computer costs are based on the assumption that the machines would be applied only to ALSEP.

Cost Comparison

	MSC	KSC
Computer Rental	$1,450,000	$700,000
Non-Computer Hardware Purchase	428,000	420,000
Support Personnel	1,650,000	786,000
Communications	0	64,000
Total	$3,528,000	$1,970,000

QUALITATIVE FACTORS

In comparing the two proposals, a number of positive and negative factors were identified. These factors are discussed briefly below.

Positive Aspects of MSC Proposal

1. The proposed IBM 360/50 computer is on rental at MSC, and would be available for the ALSEP support function. Using an existing computer is a necessity, since a new computer could not be acquired in the required time frame.

2. Software personnel with experience on real-time flight support systems and the IBM 360/50 computer are available.

3. Experienced flight control personnel are available.

*A more detailed cost comparison is included in the appendix. The costs were obtained from MSC and KSC personnel during the visits to the Centers.

4. The ALSEP program office and lunar science facility are located at MSC. Thus, ALSEP expertise is available.

5. Coordination between ALSEP flight controllers, Apollo flight controllers and Manned Space Flight Network (MSFN) controllers would be simplified.

6. Since the IBM 360/50 is compatible with the other Real Time Computer Complex Machines, excess computer time could be used for other applications. In addition, a multi-job facility is being developed for the computer which will allow one real-time job and one non-real-time job to be run on the computer at the same time. Thus, the ALSEP application could time-share the computer with a non-real-time application such as RTCC Apollo program checkout. The multi-job facility is scheduled to be available in August 1968.

7. Some detailed analysis of the proposed flight support system has been performed.

8. The ALSEP facility could be a forerunner of a sustained processing facility for the Apollo Applications Program.

Negative Aspects of MSC Proposal

1. The ALSEP flight support facility would require 5,500 square feet of floor space in a building that is already crowded.

2. Using facilities developed to support sophisticated manned space flight activities imposes a high cost overhead, when supporting a relatively simple unmanned scientific package. This fact is reflected in the cost comparison contained in this report.

Positive Aspects of KSC Proposal

1. Personnel with experience in real-time computer systems and telemetry data processing are available.

2. The flight support system would be developed specifically for ALSEP. It would not be constrained by a need to be compatible with a system developed to support manned space flight missions.

3. Floor space for the flight support facility is more than adequate.

Negative Aspects of KSC Proposal

1. The proposed SDS 930 computers are not currently available. Two SDS 930 computers are scheduled to be released by MSFC this fall, when the newly installed Univac 1108 computers become fully operational. A procurement action would have to be initiated to augment the SDS 930 computers with additional core and peripheral devices. This action, the subsequent updating of the equipment, and the movement of the computers would have to be completed by December 1, 1968, to meet the ALSEP support date. Past history of computer procurement acquisitions indicates that it may be difficult to meet this date.

2. A limited number of experienced SDS 930 software personnel are available. Additional personnel would have to be trained.

3. KSC has had difficulty in obtaining and retaining experienced programming personnel.

4. ALSEP telemetry data would still have to be provided to MSC during the deployment phase. The data would be used by MSC to assist the astronauts in deploying the ALSEP.

5. Flight control capability and ALSEP expertise would have to be developed at KSC.

CONCLUSIONS

The comparative costs for the two proposals favor KSC. Based on the assumption that the computers would be used only for ALSEP, the MSC computer costs are estimated to be twice the KSC computer costs. The cost of non-computer hardware which would have to be acquired is comparable for the two Centers. The personnel costs estimates are approximately twice as high for MSC as KSC. The costs are based on paying $10,500 per man year at KSC and $25,000 per man year at MSC.

The intangibles and qualitative factors favor MSC. Based on past experience and present capabilities, MSC appears to be the logical place to do the job. Since the computers, software personnel and flight controllers are currently available, there would be greater assurance of success if MSC is selected.

The cost of doing the job at MSC could be reduced in several ways. Since the ALSEP computer is compatible with the other RTCC computers, it could be used for other activities when it is not required for ALSEP. The computer costs would be shared by ALSEP and the other activities. By reducing the real-time support hours, the ALSEP share of the computer cost could be reduced. Reducing the capabilities of the proposed flight support system could reduce computer hardware and software costs.

RECOMMENDATIONS

We recommend that MSC be selected, contingent upon the acceptance of the cost reduction constraints listed below. If MSC can not reduce costs significantly, Headquarters should reevaluate the selection.

Constraints to Reduce Costs

1. Eliminate the digital TV display capability from the flight support system. This would reduce hardware costs by approximately $97,000, reduce support personnel cost by $75,000 and eliminate up to 15% of the load on the computer central processing unit (CPU).* The CPU time released from ALSEP support could be used for another application by making use of the IBM 360/50 multi-job capability.

2. Evaluate the following alternatives for routing the ALSEP data and commands between GSFC and MSC:

   a. Use the Communications Command and Telemetry System (CCATS) as the MSC interface with the 40.8 KBPS circuits to GSFC in lieu of purchasing two new interface terminals.

   b. Use one or two 2.4 KBPS circuits between GSFC and MSC in lieu of the 40.8 KBPS circuits.

   c. Use manual switchover if failure occurs in a 40.8 KB line, thereby saving the cost of one MSFN interface.

3. Restrict ALSEP flight support to the use of a single IBM 360/50 Computer in the Mission Control Center. Use the RTCC as a functional backup to provide a minimum real-time display capability and initiate commands manually from the remote sites.

---

*The specific hardware items which could be eliminated to reduce costs are indicated in the appendix. The $75,000 for support personnel represents an MSC estimate of three man years which could be saved in the Philco design effort.

4. Establish the concept that the IBM 360/50 computer is a multi-purpose computer, not dedicated to ALSEP. To emphasize this point, the computer hours charged to ALSEP should be identified and reported to Headquarters and the ALSEP program office at MSC. It would be helpful if a budgeting and accounting system were used in which the flight support costs could be charged directly to the ALSEP program.

5. Expedite the development of the IBM 360/50 multi-job capability. Design the ALSEP flight support program to take advantage of the capability (i.e., design a modular ALSEP program which can be reduced in size as display requests and experiment monitoring are reduced).

6. Conduct a Headquarters/MSC review of the ALSEP requirements with the objective of reducing real-time support hours.

7. Initiate a study to determine if the total complement of IBM 360 computers at MSC can be reduced.

ACKNOWLEDGEMENT

The authors hereby express their appreciation for contributions to this memorandum by Mr. R. L. Selden.

Bert H Liebowitz

B. H. Liebowitz

Robert J Pauly

R. J. Pauly

1031-$\frac{BHL}{RJP}$-pap

Attachments
Tables 1-3
Figures 1-3

TABLE 1

COMPUTER HARDWARE COST

KSC	RENTAL
SDS930 Computer	$ 4,360
Typewriter	180
Disc Storage	1,320
Card Reader	505
Tape Controller-Two Handlers	1,225
Printer (600 line/min)	915
Priority Interrupts	145
I/O Channels	665
One System	9,315
TOTAL - Two Systems	$18,630

MSC	RENTAL
360/50I	$22,352
Display System	1,700
Disc Storage	2,900
Card Reader	680
Tape Units & Control	2,170
Printers & Control	2,875
Interface Adapter	6,035
Display Adapter	586*
Subtotal	39,298
Patch Unit	1,000
TOTAL - One System	$40,298

*Item which could be eliminated to reduce costs.

TABLE 2

NON-COMPUTER HARDWARE COST

KSC		MSC	
PCM Data Converter	25K	Digital Demultiplexers	70K
Time Code Converter	5K	Encoder/Multiplexer	25K
Command Word Assembler & Parallel/Serial Converter	30K	Charactron Demultiplexer	50K*
Display Selection & Distribution	30K	MSFN Interface (2 each)	100K*
Digital Analog Converters	25K	Manual VSM	1K*
Drum Recorders	35K	81 Dac Cards	20K
Lights, Meters, Octal/ Decimal Readouts	15K	Timing Interface Unit	15K
Cable and Other Expendable Materials	20K	Drum Recorders	25K
One System	185K	Overhead Monitors	6K*
TOTAL - Two Systems	370K	Console Monitors	4K*
Spare Parts	50K	High Speed Printer	25K
Analog Tape Recorders	O.H.	VSM Scanner	15K*
Strip Chart Recorders	O.H.	Key Sets (Telephone)	72K
Analog/Digital Readouts	O.H.	TOTAL - One System	428K
Modify PCM Decommutator	O.H.	Digital Display Driver	O.H.
ANNUAL EXPENDABLES	10K	Digital to Analog Converters	O.H.
2.4 KBPS Data Circuit GSFC to KSC (2 circuits)	15,960 per. yr.	Brush Strip Chart Recorders	O.H.
GSFC to KSC Voice Circuit	5,520 per. yr.	Analog Meter Panels	O.H.
		Consoles	O.H.
		Opaque Televiewers	O.H.
		Event Panels	O.H.
		Patch Panels	O.H.
		Charactron (4 Channels)	O.H.
		40.8 KBPS Data Circuit GSFC to MSC	O.H.
		GSFC to MSC Voice Circuit	O.H.

O.H.: On Hand

*Items which could be eliminated to reduce costs. The $100K reduction by eliminating the MSFN interfaces would be partially offset by the cost of implementing the alternative approach.

TABLE 3

PERSONNEL COST

	KSC $	MSC $
Hardware Development & Integration (One Year)	*	525K Philco-21 Man Years
Software Development (One Year)	*	375K IBM-15 Man Years
Hardware Plus Software (One Year)	262K 25 Man Years	900K 36 Man Years
Annual Hardware Support (Two Years)	*	**
Annual Software Support (Two Years)	*	375K 15 Man Years
Annual Hardware Plus Software (Two Years)	262K 25 Man Years	375K 15 Man Years

* Hardware and software personnel costs were not identified separately.

** Annual hardware support personnel costs were not identified.

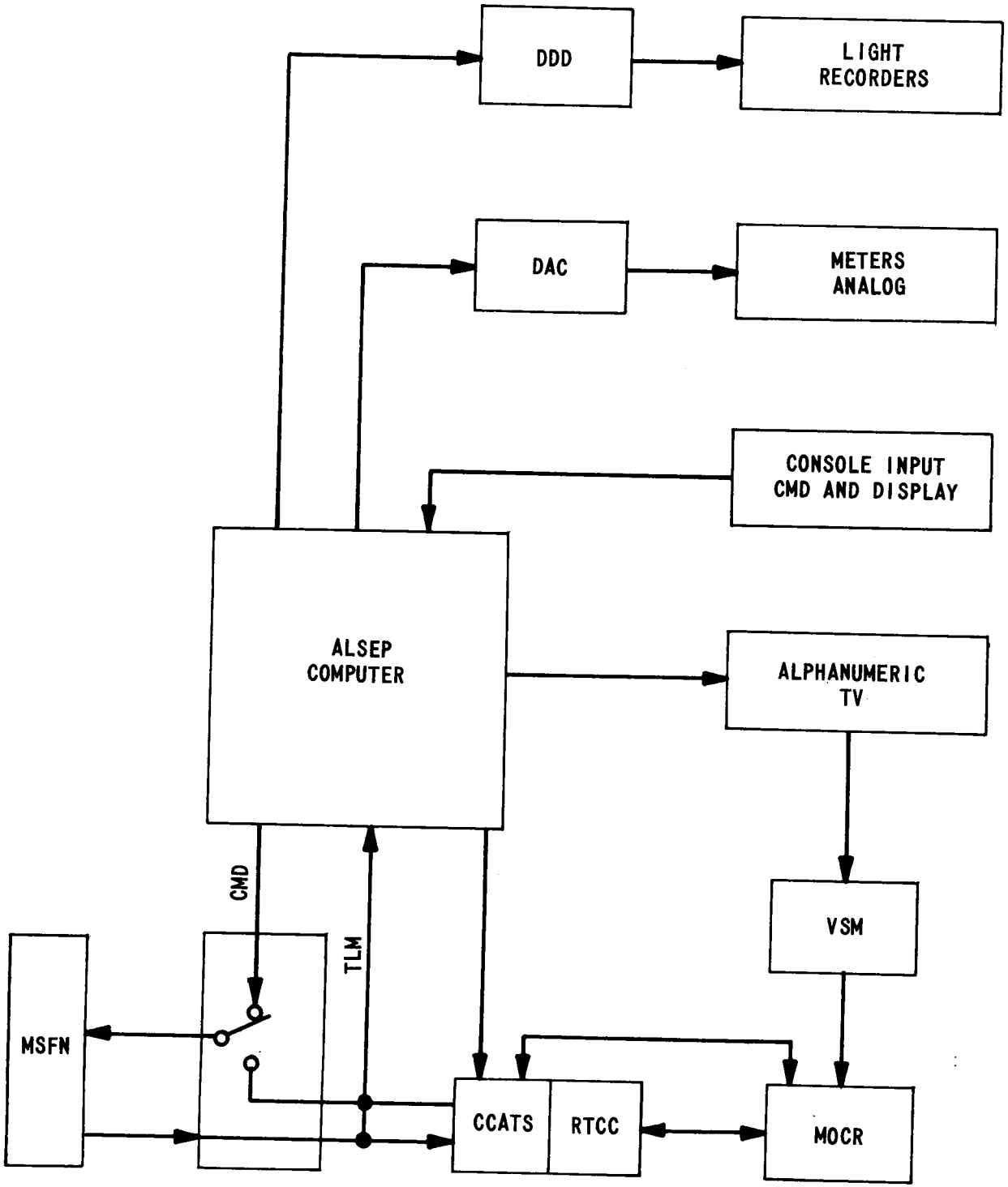

FIGURE 1 - MSC PROPOSAL

ALSEP REAL TIME COMPUTER SYSTEM
I-SYSTEM CONFIGURATION

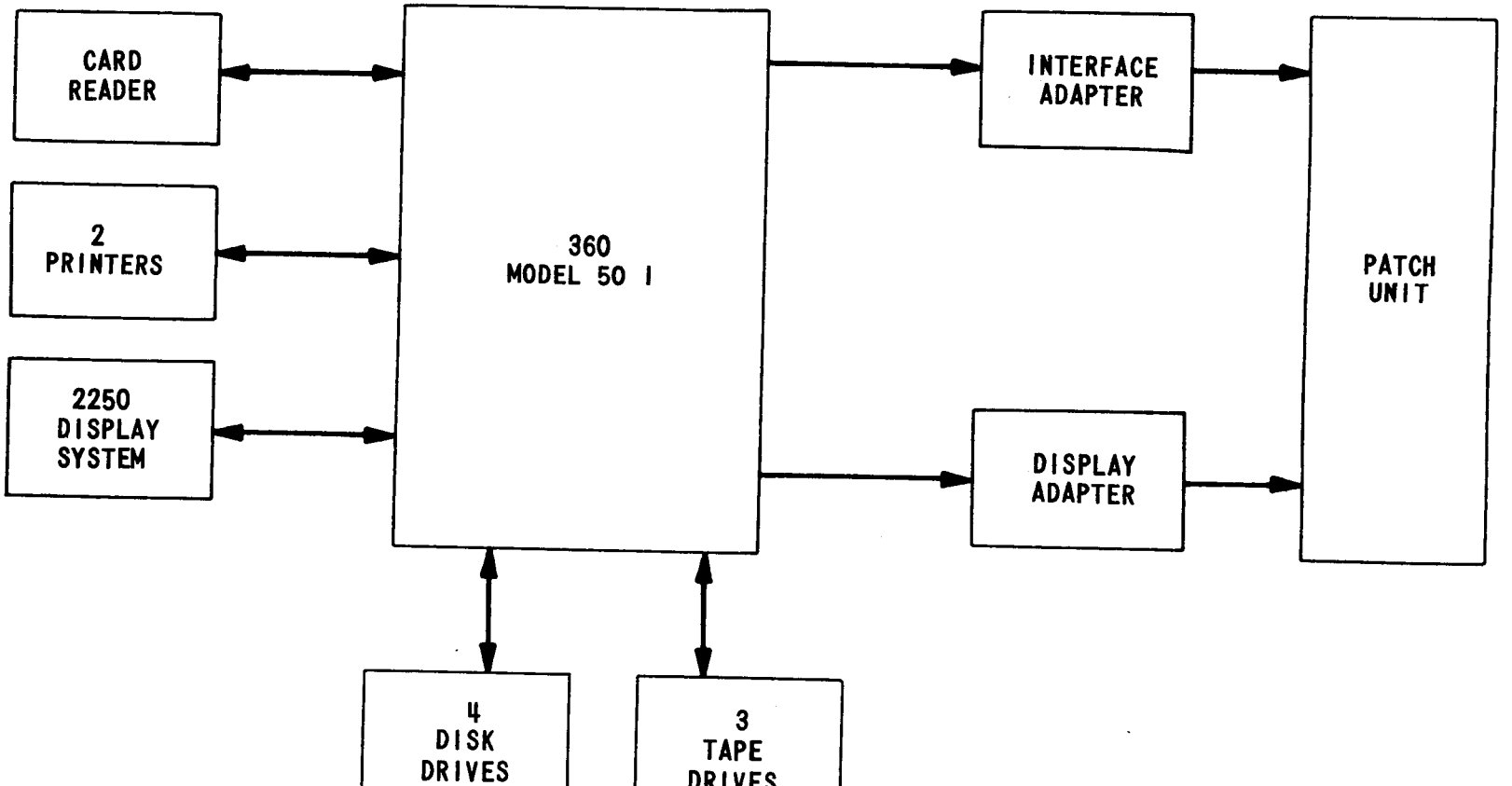

FIGURE 2 MSC PROPOSAL (COMPUTER)

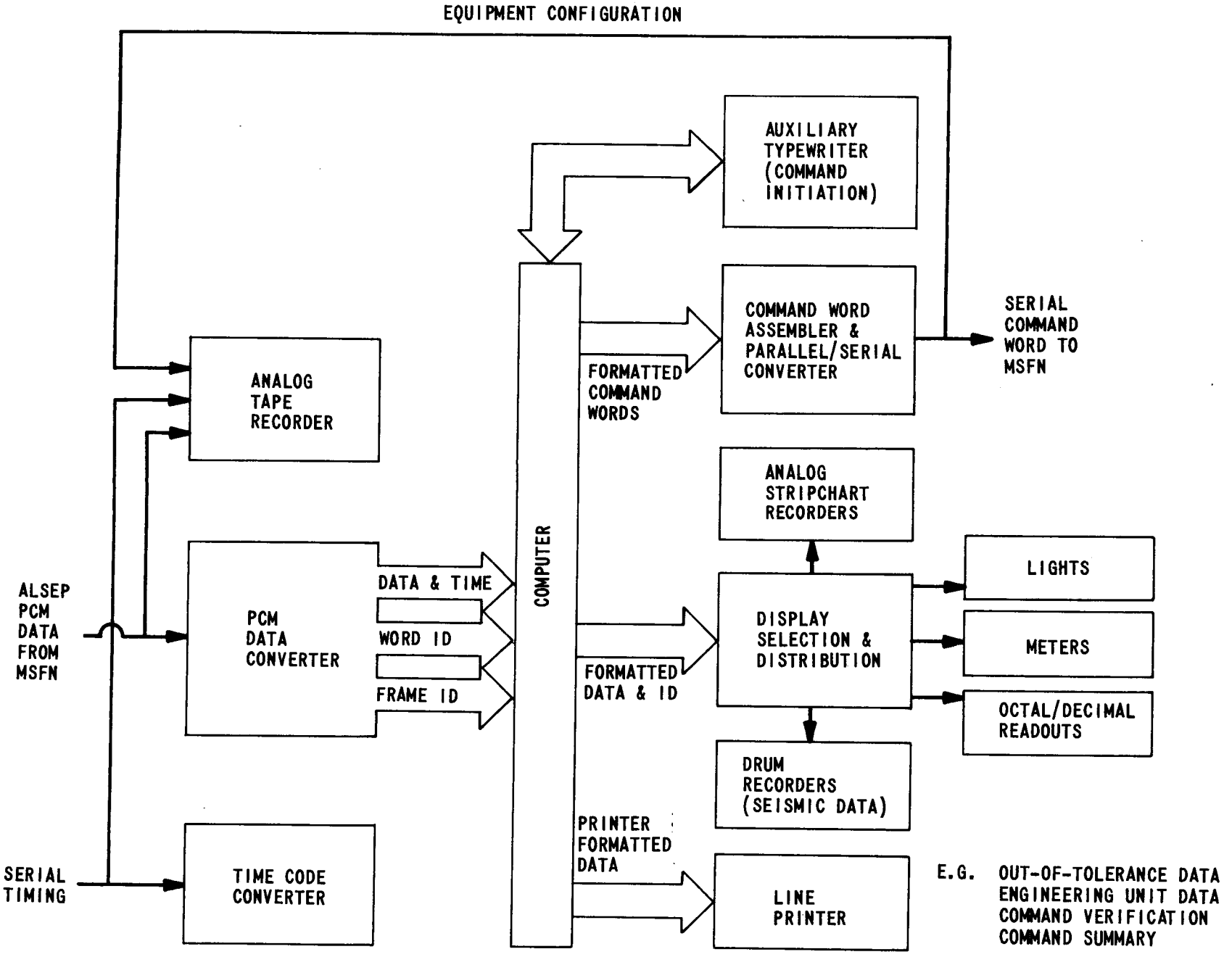

FIGURE 3 - KSC PROPOSAL